

## C-4104 Log Data Report (REVISED)

### Borehole Information:

<b>Borehole:</b> C-4104		<b>Site:</b> 241-T-106			
<b>Coordinates (WA St Plane)</b>		<b>GWL (ft)<sup>1</sup>:</b> Not applicable		<b>GWL Date:</b> 05/28/03	
<b>North</b> 136,720.82 m	<b>East</b> 566,788.42 m	<b>Drill Date</b> 05/03	<b>Ground Level Elevation</b> 675.32 (NAVD88)	<b>Total Depth (ft)</b> 127.0	<b>Type</b> Percussion

### Casing Information:

<b>Casing Type</b>	<b>Stickup (ft)</b>	<b>Outer Diameter (in.)</b>	<b>Inside Diameter (in.)</b>	<b>Thickness (in.)</b>	<b>Top (ft)</b>	<b>Bottom (ft)</b>
Threaded Steel	4.4	7	5 13/16		0	121.6
Drive Shoe	None	7	4		121.6	123

### Borehole Notes:

The logging engineer measured the casing stickup from ground surface using a steel tape. Casing diameters were measured using a steel tape and caliper on spare casings at the drill site. Measurements were rounded to the nearest 1/16 in. The driller provided casing depth and drive shoe information. The borehole was not drilled deep enough to intersect groundwater. The coordinates and ground level elevation were provided by the person in charge at the site. Logging data acquisition is referenced to the ground surface.

### Logging Equipment Information:

<b>Logging System:</b> Gamma 2E	<b>Type:</b> SGLS (70%) SN: 34TP40587A
<b>Calibration Date:</b> 03/03	<b>Calibration Reference:</b> GJO-2003-430-TAC
	<b>Logging Procedure:</b> MAC-HGLP 1.6.5, Rev. 0

<b>Logging System:</b> Gamma 1C	<b>Type:</b> HRLS (SN: 39A314)
<b>Calibration Date:</b> 04/03	<b>Calibration Reference:</b> GJO-2003-429-TAC
	<b>Logging Procedure:</b> MAC-HGLP 1.6.5, Rev. 0

<b>Logging System:</b> Gamma 2F	<b>Type:</b> NMLS (SN: H380932510)
<b>Calibration Date:</b> 02/03	<b>Calibration Reference:</b> GJO-2003-417-TAC
	<b>Logging Procedure:</b> MAC-HGLP 1.6.5, Rev. 0

**Spectral Gamma Logging System (SGLS) Log Run Information:**

Log Run	1	2	3	4 Repeat	5
Date	05/29/03	05/29/03	05/30/03	06/02/03	06/02/03
Logging Engineer	Spatz	Spatz	Spatz	Spatz	Spatz
Start Depth (ft)	122.0	84.0	63.5	91.5	18.5
Finish Depth (ft)	83.0	62.5	17.5	79.5	0.0
Count Time (sec)	150	150	150	150	150
Live/Real	R	R	R	R	R
Shield (Y/N)	N	N	N	N	N
MSA Interval (ft)	0.5	0.5	0.5	0.5	0.5
ft/min	N/A <sup>2</sup>	N/A	N/A	N/A	N/A
Pre-Verification	BE033CAB	BE033CAB	BE034CAB	BE035CAB	BE035CAB
Start File	BE033000	BE033079	BE034000	BE035000	BE035025
Finish File	BE033078	BE033122	BE034092	BE035024	BE035062
Post-Verification	BE033CAA	BE033CAA	BE034CAA	BE035CAA	BE035CAA
Depth Return Error (in.)	N/A	0	0	N/A	0
Comments	No fine-gain adjustment.	Resumed logging after 30-min. break.	No fine-gain adjustment.	No fine-gain adjustment.	No fine-gain adjustment.

**High Rate Logging System (HRLS) Log Run Information:**

Log Run	1	2	3		
Date	06/02/03	06/03/03			
Logging Engineer	Spatz	Spatz			
Start Depth (ft)	53.0	50.5			
Finish Depth (ft)	51.0	48.5			
Count Time (sec)	600	1000			
Live/Real	R	R			
Shield (Y/N)	N	N			
MSA Interval (ft)	0.5	0.5			
ft/min	N/A	N/A			
Pre-Verification	AC070CAB	AC071CAB			
Start File	AC070000	AC071000			
Finish File	AC070004	AC071004			
Post-Verification	AC070CAA	AC071CAA			
Depth Return Error (in.)	0	0			
Comments	No fine-gain adjustment.	No fine-gain adjustment.			

**Neutron Moisture Logging System (NMLS) Log Run Information:**

Log Run	1	2 Repeat	3		
Date	05/28/03	05/28/03			
Logging Engineer	Spatz	Spatz			
Start Depth (ft)	0.0	41.0			
Finish Depth (ft)	121.25	53.0			
Count Time (sec)	N/A	N/A			
Live/Real	N/A	N/A			
Shield (Y/N)	N/A	N/A			
Sample Interval (ft)	0.25	0.25			
ft/min	1.0	1.0			
Pre-Verification	BF060CAB	BF060CAB			
Start File	BF060000	BF060486			

Log Run	1	2 Repeat	3		
Finish File	BF060485	BF060534			
Post-Verification	BF060CAA	BF060CAA			
Depth Return Error (in.)	N/A	0			
Comments	No fine-gain adjustment.				

### **Logging Operation Notes:**

Spectral gamma and moisture logging were performed in this borehole during May and June 2003 on five separate days. Logging was conducted with a centralizer on the sonde. Logging measurements are referenced to ground surface. Repeat sections were collected in this borehole to evaluate system performance.

### **Analysis Notes:**

<b>Analyst:</b>	Henwood	<b>Date:</b>	06/16/03	<b>Reference:</b>	GJO-HGLP 1.6.3, Rev. 0
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Pre-run and post-run verifications for each logging system were performed for each day's log event. The acceptance criteria were met for all logging systems.

A casing correction for 0.562-in.-thick casing was applied for the 7-in. threaded steel casing to a depth of 121.6 ft. A second casing correction was applied for the 1.5-in.-thick drive shoe remaining in the bottom of the borehole from 121.6 to 123 ft. The 0.562-in. casing wall thickness is provided by CHG in "Geophysical Logging and Data Analysis Specification for T Farm Characterization."

SGLS and HRLS spectra were processed in batch mode using APTEC SUPERVISOR to identify individual energy peaks and determine count rates. Concentrations were calculated with EXCEL worksheet templates identified as G2EMar03.xls and G1CApr03.xls for the SGLS and HRLS, respectively, using efficiency functions and corrections for casing, water, and dead time as determined from annual calibrations. Dead time corrections are applied where dead times exceed 10.5 percent. Where SGLS dead time exceeds 40 percent, the HRLS may be employed and the data substituted for SGLS data. No correction for water was necessary in this borehole.

NMLS log spectra were processed in batch mode using APTEC Supervisor to determine count rates. The volume fraction of water was calculated in EXCEL, using parameters determined from analysis of recent calibration data. Zero reference was the ground surface. Data were analyzed using a uniform casing correction based on a casing thickness of 0.562 in.

$^{126}\text{Sn}$  is measured indirectly by its decay to  $^{126}\text{Sb}$ , which emits two gamma rays at 666.1 and 666.3 keV. These gamma rays have respective yields of 86 and 14 percent, respectively. Both peaks contribute to the spectral peak identified using routine processing at an approximate energy of 666 keV. The total yield for this spectral peak is 100 percent. Prior processing in T Farm (Hanford Tank Farms Vadose Zone Baseline Characterization Project) where  $^{126}\text{Sn}$  was detected used a yield of 86 percent. This would result in an overestimation of the  $^{126}\text{Sn}$  concentration by approximately 16 percent in the baseline data.

### **Log Plot Notes:**

Separate log plots are provided for the man-made radionuclides ( $^{137}\text{Cs}$ ,  $^{154}\text{Eu}$ ,  $^{152}\text{Eu}$ ,  $^{126}\text{Sn}$ , and  $^{60}\text{Co}$ ) detected in the borehole, naturally occurring radionuclides ( $^{40}\text{K}$ ,  $^{238}\text{U}$ ,  $^{232}\text{Th}$  [KUT]), a combination of man-made, KUT, and moisture, and total gamma plotted with dead time. For each radionuclide, the energy value of the spectral peak used for quantification is indicated. Unless otherwise noted, all radionuclides are plotted in picocuries per gram (pCi/g). The open circles indicate the minimum detectable level (MDL) for

each radionuclide. Error bars on each plot represent error associated with counting statistics only and do not include errors associated with the inverse efficiency function, dead time correction, casing corrections, or water corrections. Repeat log sections are also included.

## **Results and Interpretations:**

$^{137}\text{Cs}$ ,  $^{154}\text{Eu}$ ,  $^{152}\text{Eu}$ ,  $^{126}\text{Sn}$ , and  $^{60}\text{Co}$  were the man-made radionuclides detected in this borehole.  $^{137}\text{Cs}$  was detected between the ground surface and 18 ft in depth at concentrations between 0.3 and 14 pCi/g.  $^{137}\text{Cs}$  was also detected between 43.5 and 46.5 ft and between 49.5 and 51.0 ft at concentrations ranging from 3 to 38 pCi/g. The contamination may be continuous at low levels between 46.5 and 49.5 ft, where the MDLs are elevated due to high concentrations of  $^{154}\text{Eu}$  and range from 5 to 15 pCi/g.  $^{137}\text{Cs}$  was also detected at sporadic locations throughout the borehole below 51 ft near its MDL of approximately 0.2 pCi/g. The maximum concentration was approximately 38 pCi/g at 49.5 ft.

$^{60}\text{Co}$  was detected between 36.5 ft and total depth (122 ft). The maximum concentration measured was approximately 58 pCi/g at 93.5 ft.

$^{154}\text{Eu}$  was detected between 35.5 and 85.5 ft with the SGLS. The logging system dead time exceeded 40 percent in the interval between 48.5 and 50.5 ft. HRLS measurements were acquired in this interval to quantify the radionuclide concentrations. The maximum concentration measured was 1,960 pCi/g at 49.5 ft.

$^{152}\text{Eu}$  was detected between 37 and 81.5 ft with the SGLS. The interval between 81.5 and 85.5 ft where  $^{154}\text{Eu}$  was detected probably also contains  $^{152}\text{Eu}$  at concentrations below its MDL of 0.2 pCi/g. The maximum  $^{152}\text{Eu}$  concentration measured was 49 pCi/g at 49 ft in depth.

$^{126}\text{Sn}$  was detected between 43.5 and 50.5 ft. The maximum concentration was measured at 33 pCi/g at 49.5 ft.

Recognizable changes in the KUT and total gamma logs occurred in this borehole. At 37 ft, there is a 4-pCi/g increase in  $^{40}\text{K}$  concentration. This increase in apparent  $^{40}\text{K}$  concentration corresponds with the base of the backfill (Hanford H2). Although it cannot be detected in the high dead time zones, a decrease in  $^{40}\text{K}$  concentration has been observed in other T Farm boreholes to occur at 50 ft in the Hanford H2 and is a distinct transition that has been mapped in the T Tank Farm. In this borehole, the highest concentrations of radionuclides were measured at 49.5 ft. This transition from the overlying fine-grained portion of the H2 to the coarser portion of the H2 appears to influence the migration of gamma-ray-emitting radionuclides (Sobczyk 2001). Between 82 and 92 ft, the fine-grained member of the Cold Creek Unit (formerly known as the Early Palouse Soil) is shown by an 0.5-pCi/g increase in  $^{232}\text{Th}$ . A 10-pCi/g decrease in  $^{40}\text{K}$  and a 0.5-Ci/g decrease in  $^{232}\text{Th}$  concentration occur at 92 ft.  $^{238}\text{U}$  increases by more than 1.0 pCi/g in the interval between 101 and 104 ft. On the basis of low  $^{40}\text{K}$  and  $^{232}\text{Th}$  concentrations, the carbonate-rich paleosols of the Cold Creek Unit are interpreted as being between 92 and 106 ft. The top of the Ringold is picked at 107 ft.  $^{60}\text{Co}$  has reached the Ringold despite the presence of the caliche in the Cold Creek Unit.

The repeat sections indicated good agreement of the man-made radionuclides, naturally occurring KUT, and moisture.

## **References:**

Sobczyk, S.M., 2001. *Subsurface Interpretation of the T Tank Farm, Hanford Site, Washington, Based on Gamma Ray Logging*, Department of Environmental Restoration and Waste Management, Nez Perce Tribe, Lapwai, Idaho.

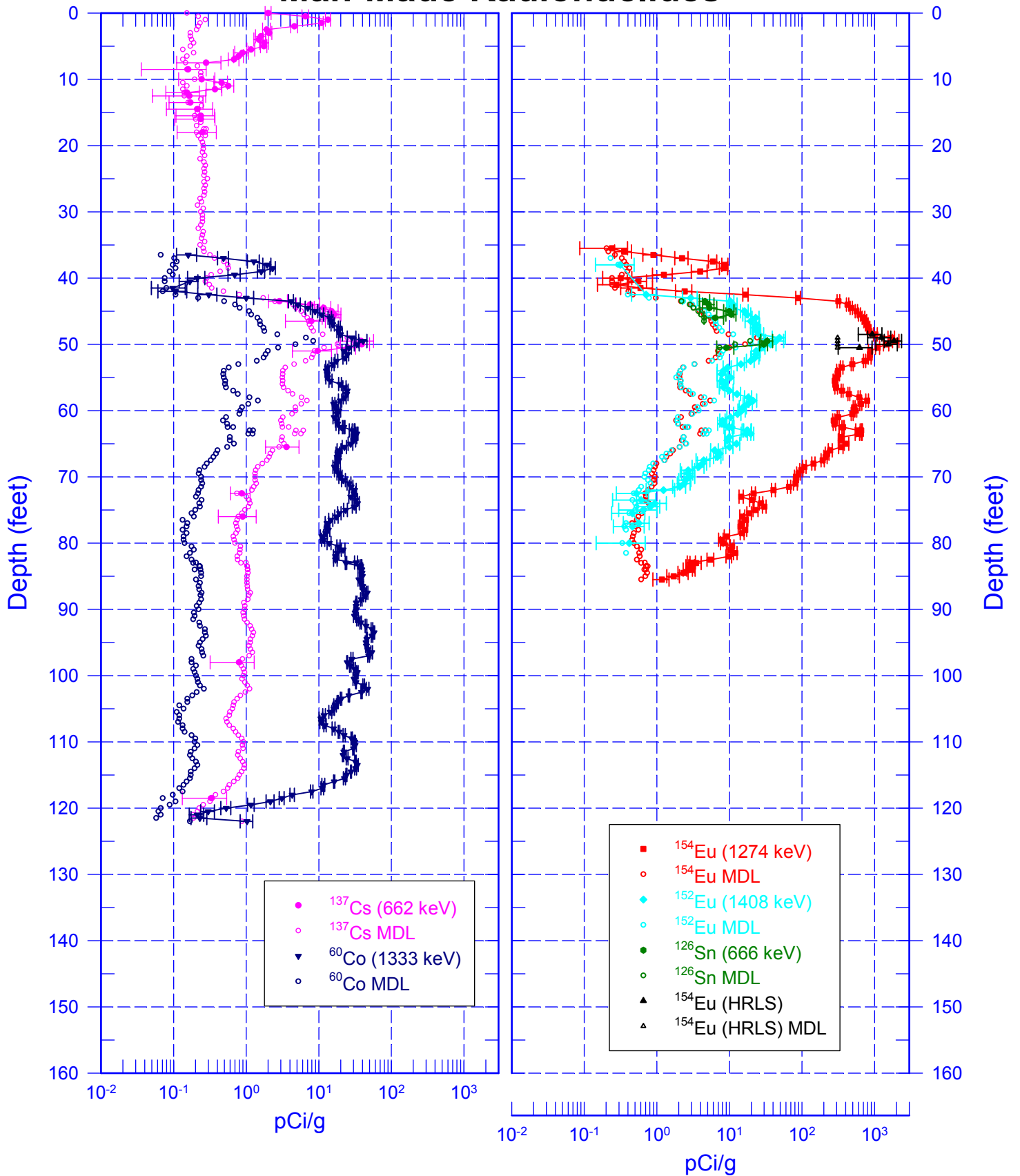
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<sup>1</sup> GWL – groundwater level

<sup>2</sup> N/A – not applicable

# C-4104

## Man-Made Radionuclides

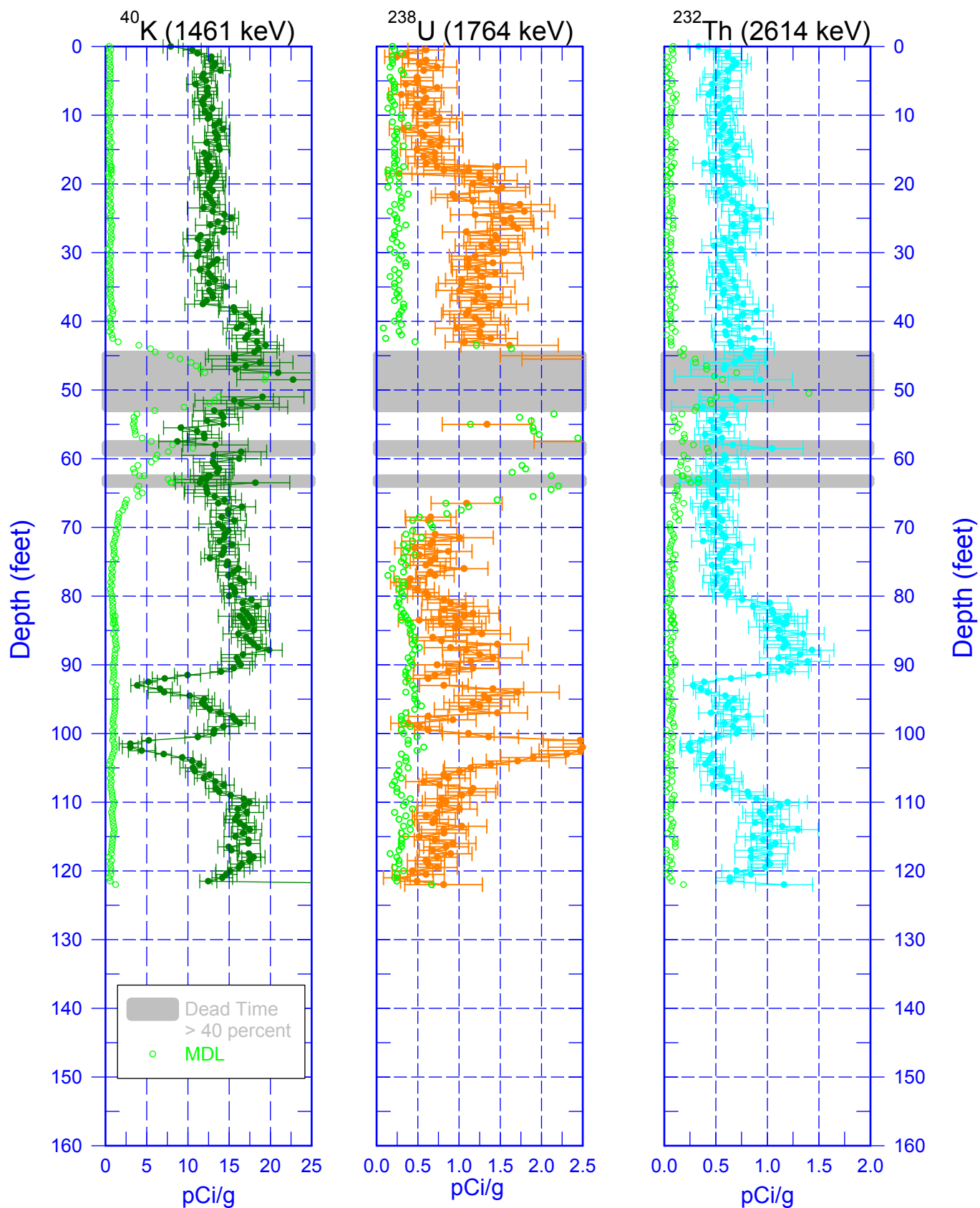


Zero Reference = Ground Surface

Last Log Date - 06/03/03

# C-4104

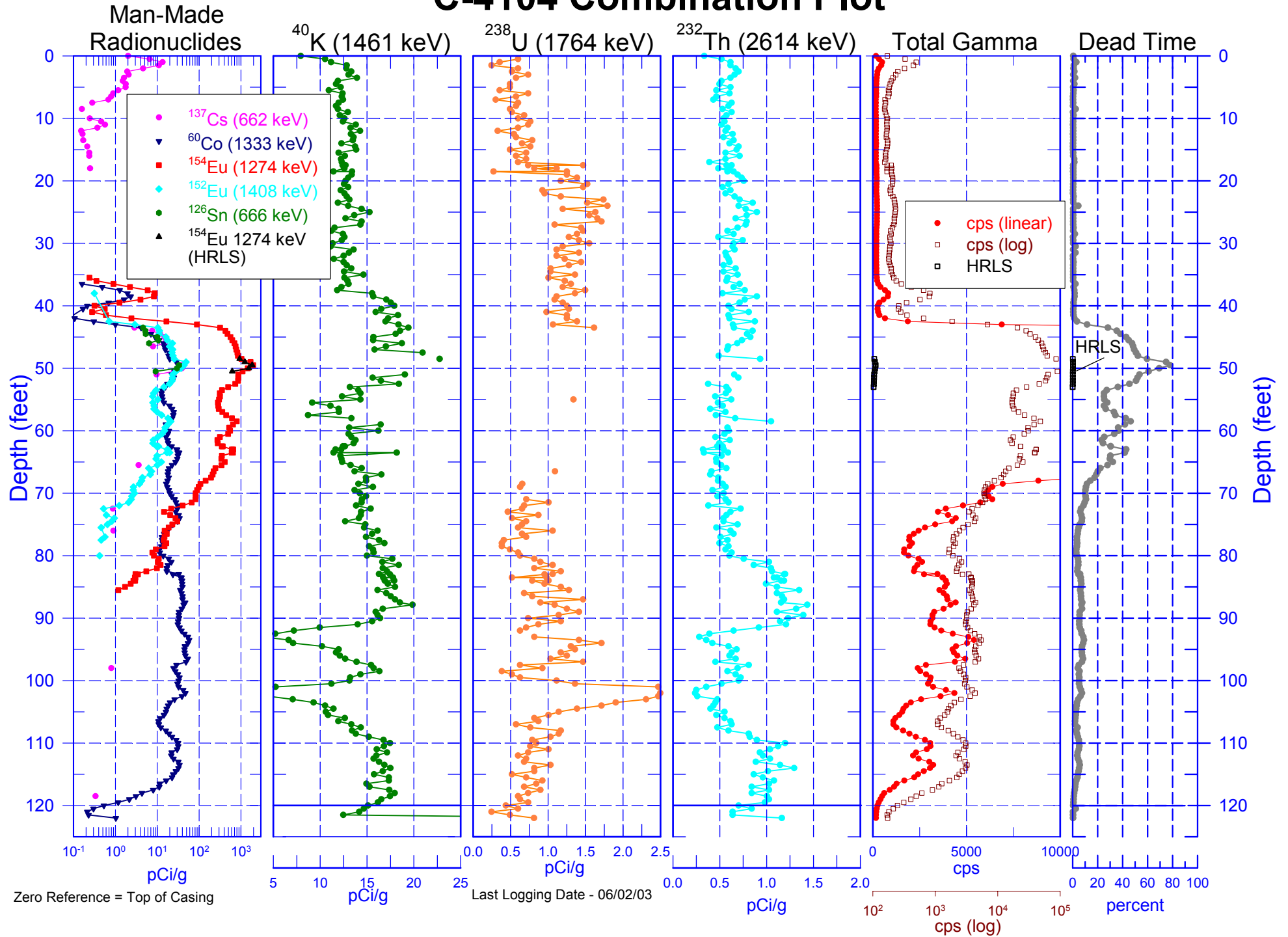
## Natural Gamma Logs



Zero Reference = Ground Surface

Last Log Date - 06/03/03

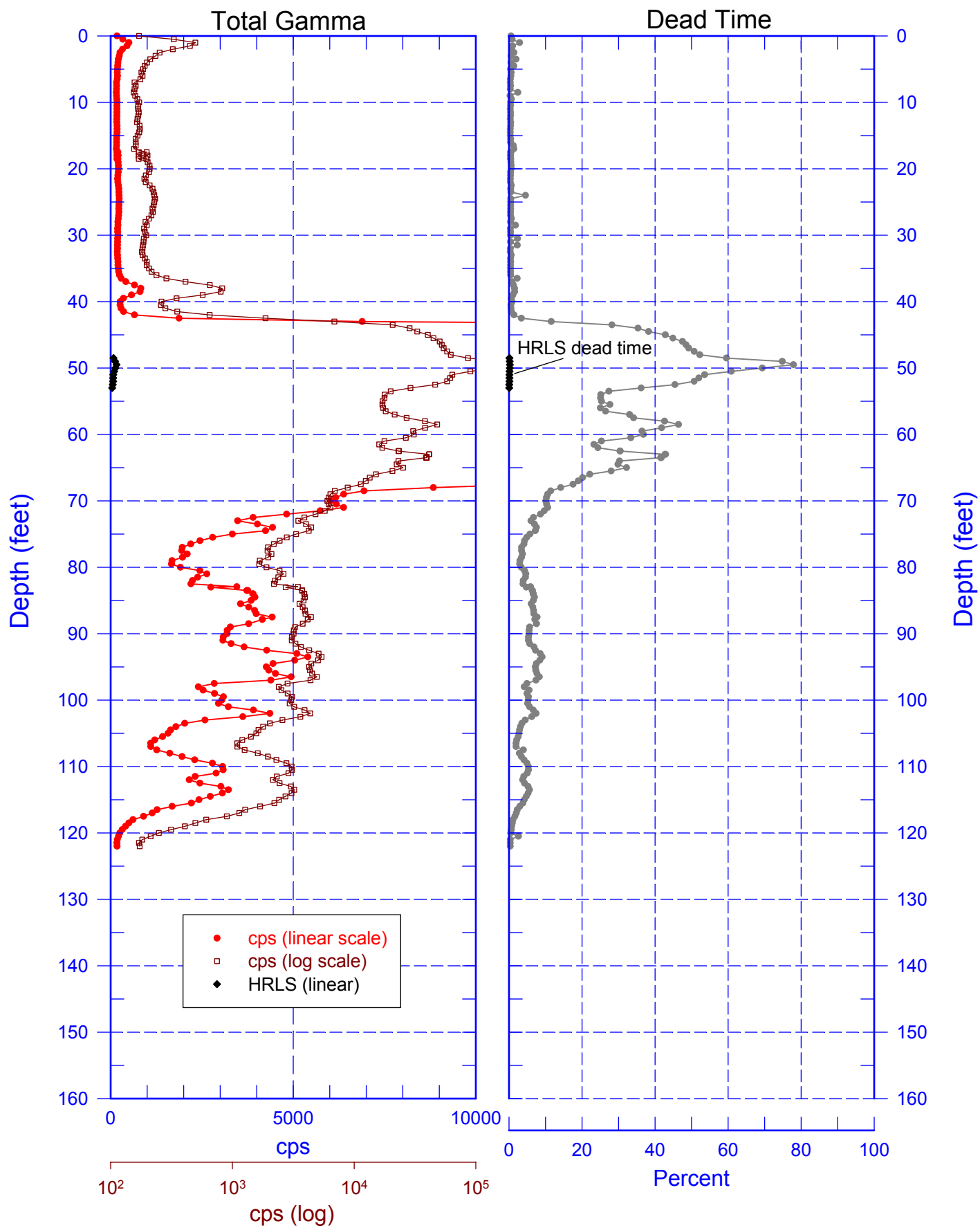
# C-4104 Combination Plot





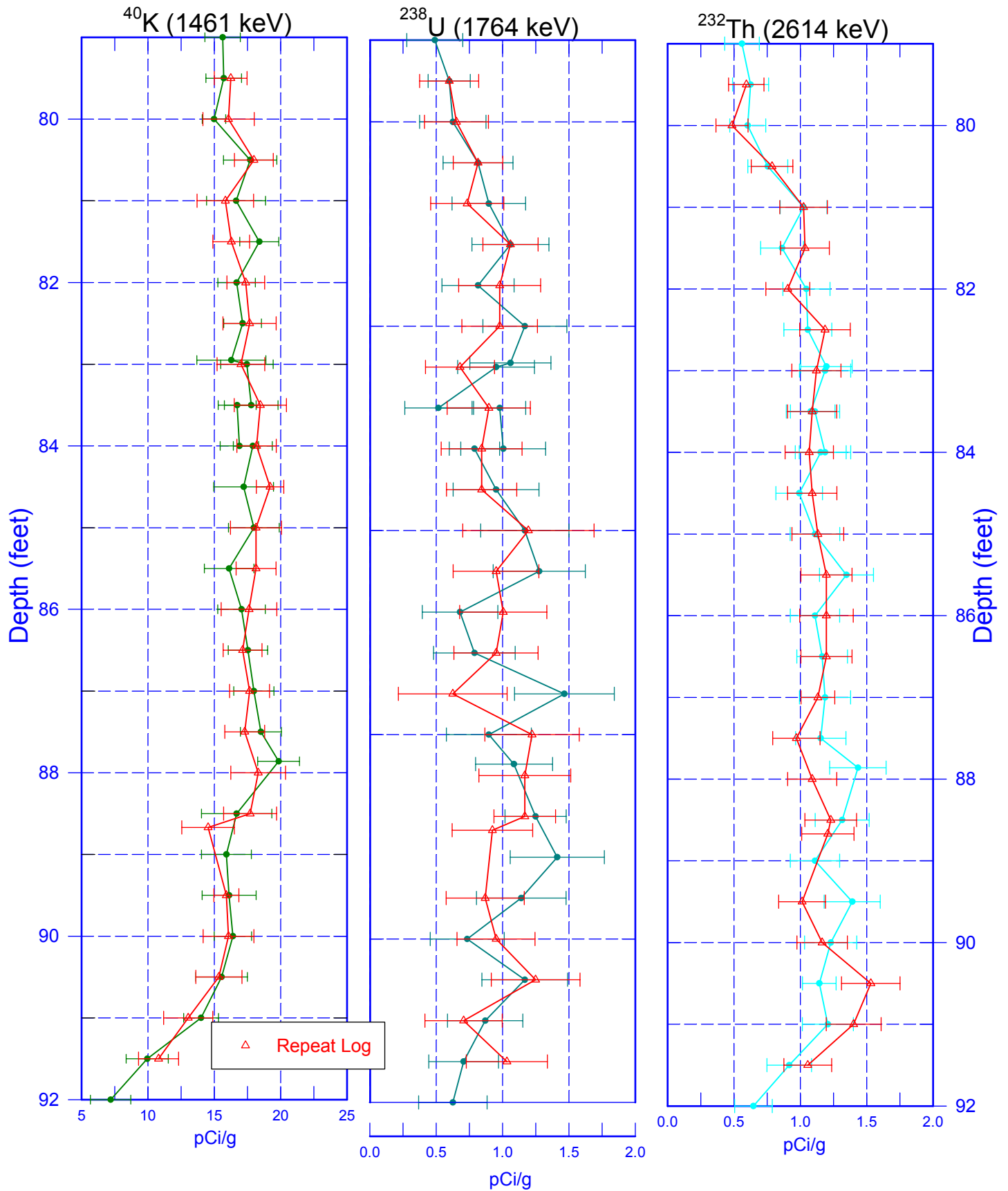
# C-4104

## Total Gamma & Dead Time



# C-4104

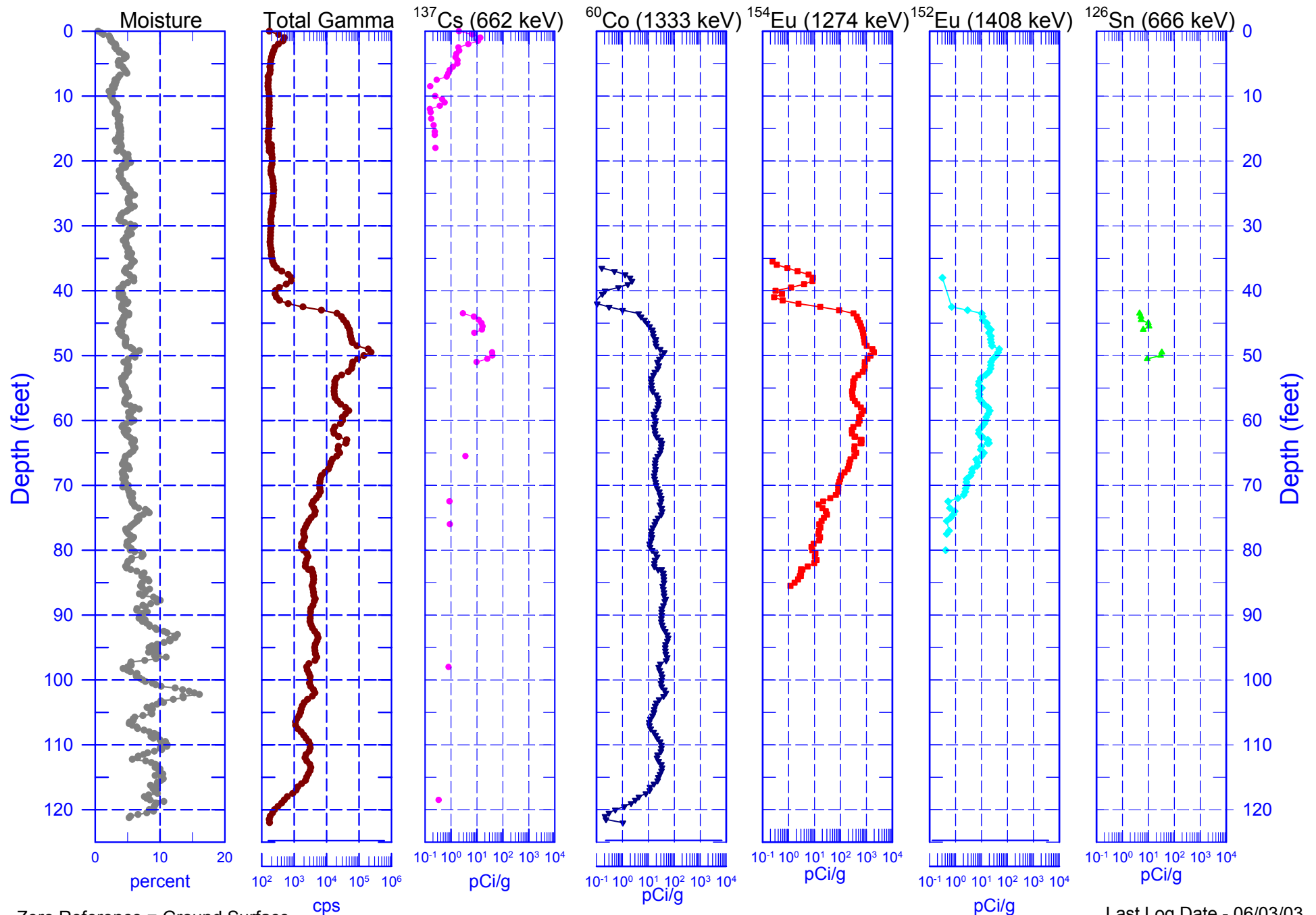
## Repeat Section of Natural Gamma Logs



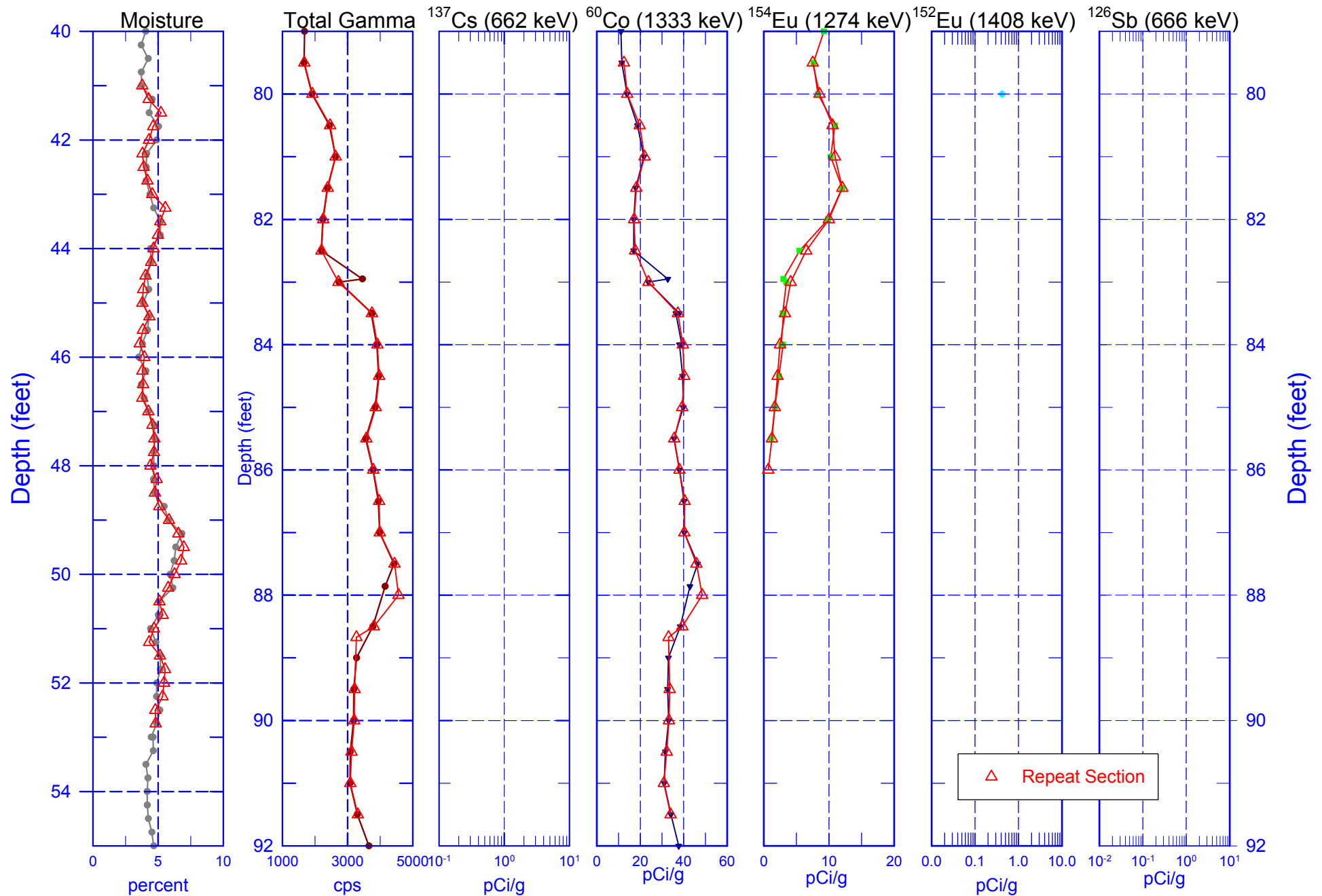
Zero Reference = Ground Surface

Last Log Date - 06/03/03

# C-4104 Spectral Gamma Ray and Moisture Log



# C-4104 Man-Made Radionuclides and Moisture Repeat Logs



Zero Reference = Ground Surface

Last Log Date - 06/03/03

# C-4104 Spectral Gamma Ray and Moisture Log

